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Free-Flyer Workshop

Exploration Technologies

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Goal C: To Develop and Validate Exploration Technology

We seek the following Research Outcomes:

Validate innovative exploration technologies for long-duration missions beyond Low Earth Orbit that cannot be validated on the ISS (OBPR 1,2,4,5)

Develop and validate countermeasures to protect life from the harmful radiation environment beyond Low Earth Orbit (minimize risks of carcinogenesis, immune deficiency and CNS damage). (OBPR 1,3,4,5)

Verify that microgravity countermeasures proven on ISS are still effective when applied in the radiation environment beyond Low Earth Orbit (OBPR 1,3,5)

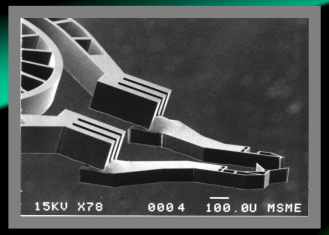
Validate hazardous and ISS-incompatible advanced spacecraft technologies (OBPR 4,5)

Goal C. To Develop and Validate Exploration Technology

We will pursue the following Research Areas:

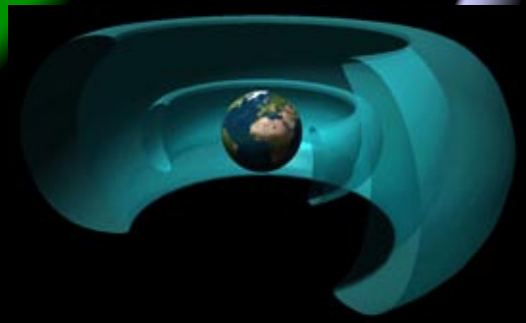
Prove that harmful µG physiological effects can be prevented

Demonstrate advanced sensors and controls



Validate critical crew life support systems

Develop new radiation shielding and countermeasure technologies



Validate advanced propulsion and power systems

Validate autonomous bio support technologies

2010 **2025**

Key Enabling Technologies

		Radiation Sources	Life Support Systems Models	Specimen Hab Systems	Mini In Situ Bio Sensors	Remote Molecular Bio-Lab	Multipurpose Biofluidics Modules	Specimen Preservation Methods	Advanced Imaging Systems	Environment Control Systems
Research Outcome 1	***Validate Innovative Exploration Technologies for Long-Duration Missions Beyond LEO***									
Research area 1	Validate autnonmous bio support technologies			●	●	●	●	●	●	●
Research area 2	Validate critical crew life support systems	●	●	●	●	●	●	●	●	●
Research Outcome 2	***Develop and Validate Countermeasures to Protect Life from Harmful Radiation***									
Research area 3	Develop nutritional and pharmaceutical countermeasures to space radiation	●		●	●	●	●	●	●	●
Research area 4	Develop new radiation shielding materials	●		●	●	●	●	●		●
Research Outcome 3	***Verify that Microgravity Countermeasures Proven on ISS Are Effective Beyond LEO***									
Research area 5	Demonstrate that muscle and bone loss can be minimized	●		●	●	●		●	●	●
Research area 6	Demonstrate that immune system health can be maintained	●		●	●	●		●	●	●
Research Outcome 4	***Validate Hazardous and ISS-Incompatible Advanced Spacecraft Technologies***									
Research area 7	Validate advanced propulsion and power systems									
Research area 8	Validate advanced sensors and autonomous control systems									

● = Technology desired/required

Key Spacecraft Capabilities

	Radiation Sources	Life Support Systems Models	Specimen Hab Systems	Mini In Situ Bio Sensors	Remote Molecular Bio-Lab	Multipurpose Biofluidics Modules
Validate Innovative Exploration Technologies for Long-Duration Missions Beyond LEO						
Validate autnonmous bio support technologies	1-6	●		●	●	
Validate critical crew life support systems	1-6	●		●	●	
Develop and Validate Countermeasures to Protect Life from Harmful Radiation						
Develop nutritional and pharmaceutical countermeasures to space radiation	1-6	●			●	
Develop new radiation shielding materials	1-6	●			●	
Verify that Microgravity Countermeasures Proven on ISS Are Effective Beyond LEO						
Demonstrate that muscle and bone loss can be minimized	1-6	●			●	
Demonstrate that immune system health can be maintained	1-6	●			●	
Validate Hazardous and ISS-Incompatible Advanced Spacecraft Technologies						
Validate advanced propulsion and power systems	1-6	●		●		
Validate advanced sensors and autonomous control systems	1-6	●		●		

● = Capabilty desired/required

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- **Validate innovative exploration technologies for long-duration missions beyond Low Earth Orbit that cannot be validated on the ISS (OBPR Organizing Questions 1,2,4,5)**

  - **Autonomous, in situ technologies to support biological systems.**
  - **Critical crew life support systems and components**
  - **Robotic technologies for in-space/in-situ fabrication, maintenance, and repair**
  - **Advanced sensors**

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- **Develop and validate countermeasures to protect life from the harmful radiation environment beyond Low Earth Orbit (minimize risks of carcinogenesis, immune deficiency and CNS damage). (OBPR Organizing Questions 1,3,4,5)**
  - **Nutritional and pharmaceutical countermeasures for space radiation**
  - **New shielding materials for beyond Low Earth Orbit.**

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- **Verify that microgravity countermeasures proven on ISS are still effective when applied in the radiation environment beyond Low Earth Orbit (OBPR Organizing Questions 1,3,5)**
  - **Determine the extent to which muscle and bone loss can be minimized (vs. "Demonstrate")**
  - **Determine the extent to which immune system health can be maintained (vs. "Demonstrate")**
  - **Test new bone-loss drugs**
  - **Test new muscle-loss drugs**

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- **Validate hazardous and ISS-incompatible advanced spacecraft technologies (OBPR Organizing Questions 4,5)**

  - **Advanced propulsion and power systems.**
  - **Advanced sensors and autonomous control systems.**
  - **Advanced bus technologies**

Space Architect's Study

2.1 Self-Sufficient Space Systems

2.1.1 Intelligent Operations
2.1.2 Advanced Platform Systems
2.1.3 Control and Communications
2.1.4 In-Situ Manufacturing
2.1.5 In-Situ Resource Excavation & Separation
2.1.6 Resource Processing & Refining
2.1.7 Surface Construction
2.1.8 Consumable Product Storage & Distribution

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Color Code for Slides 10-16:
Green = Appropriate for Free-Flyer
Orange = Doubtful or Unknown for Free-Flyer
Red = Not Appropriate for Free-Flyer

Space Architect's Study (cont'd.)

2.2 Space Utilities and Power

2.2.1 Solar Power Generation
2.2.2 Nuclear Power Generation
2.2.3 Wireless Power Transmission
2.2.4 Power Management & Distribution
2.2.5 Energy Storage
2.2.6 Cryogenic Propellant Depots
2.2.7 Thermal Materials & Management
2.2.8 Structural Concepts & Materials
2.2.9 Space Environmental Effects

Space Architect's Study (cont'd.)

2.3 Habitation, Bioastronautics, & EVA

2.3.1 EVA Systems
2.3.2 Advanced Habitation Systems
2.3.3 Advanced Life Support Systems
2.3.4 Environment Monitoring & Control
2.3.5 Human Factors & Habitability
2.3.6 Adaptation and Countermeasures
2.3.7 Space Medicine & Health Care Systems
2.3.8 Biological Risk Prediction & Mitigation
2.3.9 Biological Systems

Space Architect's Study (cont'd.)

2.4 Space Assy, Inspect, Maint, Service

2.4.1 In-Space Assembly & Construction
2.4.2 In-Space System Deployment
2.4.3 AR&C/Self-Assembling Systems
2.4.4 Inspection & Diagnostics
2.4.5 Servicing Maintainence and Repair
2.4.6 Supporting Infrastructure & Logistics
2.4.8 Robotic Archetypes

Space Architect's Study (cont'd.)

2.5 Exploration and Expeditions

2.5.1 Flying Systems
2.5.2 Surface Systems
2.5.3 "Submersibles"
2.5.4 Subsurface Access and Knowledge
2.5.5 Surface Laboratory Systems
2.5.6 Surface Environmental Effects
2.5.7 Virtual Exploration
2.5.8 ExE Technology Flight Experiment

Space Architect's Study (cont'd.)

2.6 Space Transportation (I. Earth-to-Orbit, II. In-Space, III. Target Body)

- 2.6.1 ETO Propulsion (on board)
- 2.6.2 Vehicle Airframe/Structures
- 2.6.3 Atmospheric Maneuvers and Landing
- 2.6.4 Vehicle Subsystems
- 2.6.5 In-Space Propulsion (Chemical/Thermal)
- 2.6.6 In-Space Prop (Elect, E_Magnetic)
- 2.6.7 In-Space Propulsion (Nuclear)
- 2.6.8 In-Space "Propellantless" Transfer Systems
- 2.6.9 Launch Assist/Direct Launch Systems
- 2.6.10 Launch Infrastructure & Operations.
- 2.6.11 Propulsion Test, Instrumentation & Tech
- 2.6.12 STR Technology Flight Exps

Space Architect's Study (cont'd.)

2.7 In-Space Instruments & Sensors

- 2.7.1 Detectors and Sensing Systems
- 2.7.2 Microwave Sensing Systems
- 2.7.3 Submillimeter-wave Sensing Syst.
- 2.7.4 Laser Sensing Systems
- 2.7.5 X-Ray and High Energy Sensing
- 2.7.6 Telescope Systems
- 2.7.7 In-Space Laboratory Research Systems
- 2.7.8 Instrument & Sensor Data Management
- 2.7.9 ISIS Technology Flight Experiment

Summary

- There are many opportunities to do experiments related to Exploration Technology on Free-Flyers.
- There are many opportunities for synergism between all OBPR divisions in this area.
- There are overlaps with responsibilities of other NASA enterprises, but they represent opportunities for new collaborations and synergism.
- The newly realigned Space Partnership Division, with its cross-cutting responsibilities, capabilities, and flight hardware experience stands ready to contribute fully to the Free-Flyer initiative.